Madroño, Vol. 47, No. 1, pp. 29–42, 2000

A FLORISTIC STUDY OF TSEGI CANYON, ARIZONA

Susan Holiday
Northern Arizona University, Flagstaff, AZ 86011

Abstract

The purpose of this study is to list the vascular flora present in Tsegi Canyon, Arizona, and to describe any change in flora that may have happened during the past hundred years. Plants were collected during the years 1994–1997. Three hundred and ten species representing seventy three families are reported to occur within the Tsegi drainage. Three percent of these species are endemic to the Colorado Plateau and twelve percent of the species found are non-native. A change in floristic composition is found to have occurred in the last century, correlated with a shift in habitat types in the canyon. The canyon of the late 1800's had a slowly moving stream and marshes along a continuous alluvium. The present canyon has a faster moving stream that has eroded much of the alluvium to bedrock. One species, *Cymopterus beckii* is a new report for Arizona and also is listed as a candidate for rare and endangered species status.

Floristics on the Colorado Plateau have not been widely studied, with perhaps the exception of the Grand Canyon (Phillips et al. 1987). The reason for this may be the remoteness of the area from civilization and difficulty in traveling to many parts of the plateau due to lack of roads and extremes in temperature. Although most of the plateau vegetation consists of pinion and juniper in higher elevations and desert scrub in the lower, there are also canyons which harbor a very different flora, including some relict populations, as well as seeps and alcoves with their unique flora. The purpose of this paper is to describe one of the canyons on the plateau that includes year-round, running water as a small stream, as well as seeps and alcoves.

Although this is the first compilation of flora done of Tsegi Canyon, the flora has been studied and described by various researchers previously. One of the first descriptions of the flora of the canyon was done by Clute (1920). J. T. Hack (1945) also studied the canyon as part of his documentation of the erosion/deposition cycles in northern Arizona. He, along with Dean (1969) and Weatherill (1953) describe the erosion of this area that occurred within the last hundred years, which could possibly be related to the environmental changes that occurred in the southwest during the first part of the century (Hastings & Turner, 1965). An inventory was done for the park service in the 1970's, with Brotherson et al. (1978) publishing a flora of Navajo National Monument. Historical collections were examined at the Walter B. McDougall Herbarium, the Deaver Herbarium, the U. of A. Herbarium, and at the herbarium at Navajo National Monument.

Study area description. The Tsegi Canyon drainage system is a complex of canyons that forms the headwaters of Laguna Creek, one water supply for the town of Kayenta, AZ. Tsegi Canyon, whose name in the Navajo language means 'in the rocks' or canyon, is in Navajo County in the northeast corner of Arizona, 540000E, 4054000N, 36°40′N, 110°30′W. Tsegi Canyon includes in its boundaries two of the three sections of Navajo National Monument, Betatakin and Keet Seel.

The head of Tsegi Canyon is located on the Organ Rock Monocline. This is an uplift that is followed by Highway 160, in Long Valley between the Shonto Plateau and Black Mesa. The canyon is a complex drainage cut into the Shonto Plateau on the east and Skeleton Mesa to the west. Six different geological formations are visible in the canyon. The top of the plateau is made of Navajo Sandstone, the formation responsible for the magnificent sandstone cliffs at the top of the canyon. This layer is of Jurassic age and made of wind-blown sand and dunes. The layer just under the Navajo Sandstone is the Kayenta formation consisting of gray-red sandstone and some clay shale. This layer is about 61 meters thick at the head of the canyon. Because the Navajo sandstone is porous, it allows percolation of water onto the top of the less porous Kayenta formation. The water moves laterally over the Kayenta formation to flow out and form seeps on the canyon walls. Exfoliation of the sandstone above the seeps causes the formation of the alcoves that were utilized by the Anasazi. The layers under the Kayenta formation are a part of the Glen Canyon group. In the canyon, it is represented by the Lukachukai member of the Wingate sandstone. This is a reddish-brown, cliff-forming sandstone often responsible for the rockfall in the canyon. Under this is the Chinle formation. It is represented by two strata, the Churchrock member and the Owlrock member. The Churchrock member consists of brownish-red siltstone, mudstone, and fine-grained sandstone with small, white spots and streaks. Below is the Owlrock member which consists of reddish-brown siltstone and mudstone, and greenish-gray claystone laid down in the Triassic Age. There is also a limited exposure located north of the Tsegi Hotel, of Petrified Forest member with red, purple, and green/gray betonite claystone. On

the bottom of the canyon is alluvial fill (Beaumont & Dixon 1964).

There are three layers of alluvial deposition in Tsegi Canyon. The oldest layer is the Jeddito formation that was laid down before 3500 BC. This is overlaid by the Tsegi formation that was laid down between 3500 BC and AD 1300. The youngest layer of alluvium is the Naha formation that was laid down between 1450 and 1880 (Hack 1945). Although there is a small amount of post-1900 alluvium, at the present there is more erosion happening than deposition. The reasons for the deposition and erosion cycles is not definitely known. It has been suggested that rainfall, climate fluctuations, and land management practices may all be contributors to this cycle, with perhaps, the climate being the most influential factor (Clay-Poole 1989). However there is also evidence that human activity has affected arroyo cutting in the canyon. The cutting of the Tsegi-Naha arroyo in Keet Seel was preceded by the clearing of an aspen forest at the bottom of the canyon in the 1200's. After the abandonment of Keep Seel, the area was redeposited with alluvium and recolonized by *Quercus gambelii* (Dean 1969). However, with the new arroyo cutting of the present century, the distribution of oaks have retreated to the upper side alluvium.

The climate at Tsegi Canyon is arid with cold winters and hot summers. The daily average temperature at Tsegi is Celsius. Temperatures vary from highs of 340 to 380° C in July to lows of −230 to 130° C in the winter. The frost-free season averages about 155 days. Precipitation in the canyon is variable from year to year. Over a 17-year span, the rainfall at the Betatakin Monument ranged from a low to 17.3 centimeters to a high of 47.7 centimeters (U.S.D.C. 1979–1996). The variability is caused by differences in winter precipitation and is also enhanced by the fact that monsoon rains are very spotty and usually do not equally wet all parts of the canyon (Dean 1969).

Methods

Seventeen collecting trips to Tsegi Canyon were made between 1994 and 1997. The main focus of collecting was to include as many species as possible for the floristic list. The collections were done between the months of April and October, as most of the vascular flora is dormant during the winter. Lower Tsegi Canyon was visited April 23, 1994; May 30, 1994; July 16, 1994; and August 12, 1994. Wildcat Canyon and Lone Cottonwood Canyon were visited June 19, 1995, July 26, 1995, and August 11, 1995. Upper Tsegi Canyon, Fir and Betatakin Canyon were visited June 3, 1994; August 7, 1994; September 16, 1994; May 21, 1995; May 29, 1996; and August 8, 1996. Dowozhiebito and Keet Seel Canyons were visited June 18, 1994; May 5, 1996; September 28, 1996; and June 26, 1997. Four of the trips, May 29, 1996; August 8, 1996; September 28, 1996; and June 26, 1997 were made at the request of the National Park Service as a survey for rare and endangered species. At this time, collections were made at Betatakin National Monument and Keet Seel National Monument. However, the majority of the collecting was done on Navajo Tribal land.

All specimens were pressed, dried, and stored at the Deaver Herbarium (ASC) at Northern Arizona University, with duplicates sent to the Navajo Tribal Heritage Herbarium. Specimens were named following Kartesz (1994). Previous collections located at the Deaver Herbarium (ASC), the museum of Northern Arizona Herbarium (MNA), and the University of Arizona Herbarium (ARIZ) were used for comparison.

A classification model, modified from Rowlands' Colorado Plateau Vegetation Assessment and Classification Manual was used to describe the various vegetation assemblages in the canyon. I determined dominant/co-dominants by using the largest sized plants that appeared to be the most abundant (Bonham 1989; Rowlands 1994). The other notable species are included to help describe the assemblages. Boundaries were determined using physical boundaries, such as terrace levels and natural altitudinal separations. The assemblages were mapped out using USGS topographic maps of the Betatakin, Keet Seel, and Marsh Pass quadrangles with additional information relating to location and size taken from aerial photos. The maps were drawn by hand and the areas of the vegetation assemblages determined using a Mackintosh scanner and NIH Image area analysis.

Results

There were 310 species found in Tsegi Canyon during the study years. In comparison, 518 species were found in Canyon deChelly National Monument (Halse 1973; Harlan 1976), 293 species were found at Navajo National Monument (Brotherson 1978), 376 species were found in Volunteer and Sycamore Canyon (Shilling 1980), and 326 species were found in the Walnut Canyon National Monument (Arnberger 1947; Spangle 1953; Joyce 1976). There are eight vegetation assemblages described in this study for Tsegi Canyon which include the *Pseudotsuga* assemblage, *Populus tremuliodes* assemblage, the *Pinus edulis/Juniperus osteosperma* assemblage, *Quercus gambelii* assemblage, *Atriplex/Artemisia* assemblage, the *Juncus* marshland assemblage, *Betula occidentalis* assemblage, the *Gutierrezia* assemblage, and the *Pucinnellia* badlands assemblage. This classification is split into more detail than the USFS digitized classification system (Brown 1980) and some of the assemblages are combined compared to Rowlands (1994). Because there is no standardized way to classify the complex systems of a riparian canyon on the Colorado Plateau, this scheme was created based on both classification systems.

Pseudotsuga occurred in shaded, mostly north and west facing areas in the side canyons of Tsegi. This assemblage consists of about 8% of the total coverage of vegetation sampled in the canyon. Most *Pseudotsuga menziesii* individuals encountered were older trees. A study of whether or not seedlings are present in high enough numbers to replace older trees would be of value for this area. The *Pseudotsuga* often graded down into populations of *Populus tremuliodes* in the moist side canyons, and sometimes an individual fir could be found in the upper regions of a stream bed. Rarely, *Pinus ponderosa* could be found growing among the firs. In the upper Keet Seel canyon, few individuals of *Abies concolor* were found among the fir. Shrubs growing in this assemblage include *Ssymphoricarpos oreophilius, Ribes cereum, Ribes inerme,* and *Amelanchier alnifolia.* Herbaceous plants include *Antennaria parvifolia, Mahonia repens, Corydalis aurea, Galium aparine,* and *Valeriana acutiloba.* This assemblage is included in the Cold Temperate Forest and Woodlands, Rocky Mountain Montane Conifer Forest, Douglas fir-White Fir series, 122.311. *Pseudotsuga menziesii* Association in the Digitized Systematic Classification used by the Forest Service (Brown 1980). In Rowlands (1994), this is part of the Montane Zone, Forest and Woodland Formation, and *Pseudotsuga menziesii* Series.

Populus tremuloides creek bottoms include plants adapted to a shady, moist environment. *Populus tremuloides* covers less than 1% of the area studied, occurring in the upper areas of the Betatakin-Fir Canyon side canyons. This assemblage is bounded above mostly by *Pseudotsuga menziesii* on the shady sides of the canyons and *Quercus gambelii* on the more sunny sides. *Betula occidentalis* can be found further down the creek bed if there is running water, otherwise it usually ends abruptly in *Pinus/Juniperus* or sandy creek bottom vegetation. Other trees that can be found in this assemblage include *Pseudotsuga menziesii* and *Prunus virginiana.* Shrubs present include *Rhus aromatica, Symphoricarpos oreophilus, Cornus sericea, Arctostaphylos pungens, Ribes leptanthum, Rosa woodsii, Salix exigua,* and *Salix lasiolepis.* Herbaceous plants include *Equisetum arvense, Carex athostachya, Eleocharis palustris, Juncus arcticus, Fritillaria atropurpurea, Smilacina stellata, Poa praatensis, Erigeron speciosus, Silene menziesii, Lathyrus brachycalyz, Androsace septentrionalis, Clematis ligusticfolia, Thalictrum fendleri, Heuchera parvifolia,* and *Mimulus rubellus.* The closest classification of this assemblage found in the USFS classification is the Great Basin Interior Strand, which is very non-specific (Brown 1980). Rowlands (1994) has a *Populus tremuloides* Series in his Forest and Woodlands Formation. However, I do not feel that this quite fits as it describes aspen in a pine forest where the pines will eventually succeed the aspen. Here the aspen are the climax species, with aspen saplings replacing older trees.

The most common assemblage found on the Shonto Plateau is the *Pinus edulis/Juniperus osteosperma.* This assemblage forms 50% of the plant communities mapped. In the canyon, this assemblage is found in many of the upper ledges and south facing canyon sides. This assemblage surrounds the Monument headquarters and is common on the top of Skeleton Mesa. Shrubs that can be found in association with this assemblage include *Ephedra viridis, Chrysothamnus nauseosus, Shepherdia rotundifolia, Fendleera rupicola, Amelanchier utahensis, Cercocarpus intricatus, Cerccocarpus montanus, Holodiscus dumosus,* and *Yucca angustissima.* Herbaceous plants include *Allium macropetalum, Calochortus aureus, Bouteloua gracilis, Cymopterus acaulis, Artemisia dracunculus, Psilostrophe sparsiflora, Heterotheca villosa, Arabis perennans, Streptanthus cordatus, Echinocereus triglochidiatus, Opuntia polycantha, Astragalus ceramicus, Mirabilis multiflora, Ipomopsis aggregata, Castilleja linariifolia, Cordylanthus wrightii,* and the parasitic *Phoradendron juniperinum.* The *Pinus edulis/Juniperus osteospermus* assemblage is part of the Forest and Woodland Formation (Rowlands 1994) and classified by the USFS as part of the Great Basin Conifer Woodland, Pinion-Juniper Series (Brown 1980).

The area described as the *Quercus gambelii* assemblage occurs on the upper terraces in side canyons draining from west to east, though there are exceptions in the upper areas included in this study. This assemblage is estimated to cover about 2% of the study area. The main component of this assemblage are thickets of *Quercus gambelii* with occasional larger trees of *Quercus* included. This area's shading consists of thick leaf litter and generally is not as diverse as the more expansive *Pinus/Juniperus* assemblage. Many plants found here grow in spaces in the thicket where more light can penetrate. Other shrubs included in this assemblage are *Ribes cereum* and *Prunus virginiana.* The herbaceous cover includes *Juncus arcticus, Smilacinia stellata, Bouteloua curtipendula, Opuntia phaeacantha, Erigeron utahensis,* and *Lathyrus brachycalyx.* Rowlands (1994) classifies this as the Tall Shrubland Formation, *Quercus gambilii* Series. The USFS Digitized Classification (Brown 1980) includes this in the Cold Temperate Scrublands, Great Basin Montane Scrub, Oak-Scrub Series.

The *Atriplex/Artemisia* assemblage dominate on the lower terraces above the main creek and at the mouths of the side canyons. This is the second largest vegetation assemblage covering about 22% of the total canyon. Although there may be an occasional Pinion or Juniper tree associated with this assemblage, the dominant larger plants are the shrubs *Atriplex canescens* and *Artemisia tridentata.* There are also occasional lone *Elaegnus angustifolia* individuals of unknown origin, possibly planted by members of the family that use the canyon (Melberg 1988), or distributed by birds. There is also a small stand of about four *Ulmus pumila* at

one site, planted along the side of the dirt road. Shrubs associated with this area include *chrysothamnus viscidiflorus, Sarcobatus vermiculaatus, Poliomintha incana,* and *Cercocarpus intricatus.* Herbaceous plants include *Elymus smithii, Artemisia frigida, Helianthus peetiolaris, Senecio multilobatus, Cryptantha crassisepala, Descurainia pinnata, Salsola iberica, Astragalus amphioxys, Phacelia ivesiana, Spaeralcea parvifolia, Mirabilis oxybaphoides, Gayophytum racemosum, Orobanche multiflora, Erigonum cernuum, Ranunculus testiculatus,* and *Verbeena bracteata.* Rowlands (1994) split these two shrub species into two separate series in his classification scheme. However, in Tsegi Canyon, the two species were found in many places together, and thus would be hard to separate into separate assemblages. The closest classification found in the USFS classification manual (Brown 1980) is defined as the Cold Temperate Desertlands, Great Basin Desertscrub, Mixed Scrub Series.

The *Juncus* marshland assemblages were usually found at the bottoms of most small side creek drainages and flattened areas below seeps. The *Juncus* assemblage is a minor component of the canyon, consisting of less than 1% of the canyon surveyed. These areas were often heavily used by cattle and damaged by trampling. This assemblage had only occasional *Elaeagnus angustifolia* or *Tamarix ramosissima.* There was also one example of a *Populus fremonti* tree at the edge of one marshland. Herbs found in this assemblage include *Juncus arcticus, Equisetum arvense, Polypogon monspeliensis, Scirpus pungens, Aster frondosus, Conyza canadensis, Taraxacum officinale, Crypthantha inaequata, Lepidium virginicum, Epilobium ciliatum, Plantago major,* and *Ranunculus cymbalaria.* Rowlands (1994) classifies this as a Marshland Formation, *Juncus arcticus* Series. Using the USFS classification this assemblage would be included in the Cold Temperate Marshlands, Great Basin Interior Marshland, Rush Series (Brown 1980).

Betula occidentalis creek bottom assemblage was found only in the areas of Betatakin-Fir Canyon drainages and some north-draining side canyons of Keet Seel and upper Dowozhiebito Canyon. This assemblage accounted for about 1% of the area mapped. In the Betatakin area it was bounded above by *Populus tremuoides* and below by *Elaeagnus angustifolia.* In other side-canyons, *Betula* was the uppermost tree species on the drainage floor. The *Betula* commonly grew along both sides of drainages that included year-round running water. Another tree species associated with this assemblage was *Acer negundo. Salix monticola* and *S. lasiolepis* were also found growing among the birches. Herbaceous plants found in this assemblage include *Corallorhiza maculata, Toxicodendron rydbergii,* and *Chenopodium album.* Like the *Quercus* assemblage, the density of the trees tend to shade the floor of the creek. This, along with occasional high water levels, tend to limit the number of herbs present. Rowlands (1994) classifies this in the Montane Zone, Tall Shrubland Formation, *Betula occidentalis* series. However, this would be more applicable if it was placed in a riparian formation, which is not included in this classification scheme. In the USFS (Brown 1980) there is a Cold Temperate, Great Basin Interior Strand, which includes all riparian vegetation in the Great Basin Biome.

The bottoms of the major drainages are classified as the *Gutierrezia* stream bottom assemblage. This assemblage covers about 18% of the canyon. The soils in this area are characterized by sandy deposits that are typically scoured at least once a year by flooding. There is also quicksand after floods and other areas that are devoid of vegetation because of animal or human (automobile) use. This assemblage also includes areas of bare sandstone and low, dry, sandy dunes. Shrubs that grow here include *Gutierrezia sarothrae, Chrysothamnus depressus,* and *Artemisia frigida.* Herb species that grow here include *Equisetum hyemale, Chenopodium leptophyllum, Salsola iberica, Astragalus amphioxys, Nama retrorsum, Tripterocalyx micranthus, Oenothera pallida,* and *Verbascum thapsus.* Rowlands (1994) has a *Gutierrezia sarothrae* series in his classification under the Low Shrubland Formation. The USFS (Brown 1980) includes this area under the Great Basin Interior Strand.

Downstream the *Betula* individuals in the Betatakin drainage is a stand of *Elaeagnus angustifolia.* Here, *E. angustifolia* is growing along both sides of the creek. Whether *E. angustifolia* is displacing the birch or growing in an area that is for some reason too low in the drainage for the birch is unknown. However, since *E. angustifolia* is an introduced species, and there is an area of interface between the two species, and because the Elaeagnus seems to be spreading in the canyon (Melberg, 1994), the former possibility needs to be examined. Elsewhere in the canyon, *E. angustifolia* is mostly present as individual trees or young plants. Young plants were found growing in the Keet Seel drainage, about seven miles from Betatakin, and other young plants were found in side canyons across and above the Betatakin drainage. This is one species that needs to be watched closely because it seems to be able to colonize some local areas and possibly out-compete native growth.

The *Puccinellia* assemblage consists of few plant species growing on betonite clays. This assemblage covers less than 1% of the area mapped. The largest example of this assemblage is in upper Wildcat Canyon on the north-west facing side of the canyon. Most of the plants are concentrated near a small seep. The area grades into the *Pinus/Juniperus* assemblage above it on the canyon sides. Plants included here are *Apocynum cannabinum* and *Puccinellia distans.* The closest classification in Rowlands (1994) would probably be the Submontane Barren Formation 1408.03. In the USFS

TABLE 1. A COMPARISON OF THE TEN LARGEST FAMILIES OF VASCULAR FLORA OF TSEGI CANYON, PETRIFIED FOREST, N.P., CAPITOL REEF N.P., GRAND CANYON N.P., AND THE NAVAJO NATION. *Family not in top ten % flora, [1]Kierstead, 1981, [2]Heil et al., 1993, [3]Phillips et. al., 1987, [4]Mayes and Rominger, 1994.

Family	Tsegi Canyon	Petrified[1] Forest N.P.	Capital[2] Reef N.P.	Grand[3] Canyon N.P.	Navajo[4] Nation
Asteraceae	19.0	19.9	20.4	16.6	17.6
Poaceae	11.2	19.6	14.0	11.3	11.7
Brassicaceae	5.5	4.7	6.3	4.6	4.9
Fabaceae	5.2	5.6	8.4	4.8	8.1
Scrophulariacea	3.3	*	3.5	3.1	3.3
Chenopodiaceae	3.5	6.8	3.9	*	3.1
Rosaceae	3.2	*	*	2.3	2.5
Boraginaceae	2.9	*	*	3.0	2.3
Cactaceae	2.5	*	*	*	*
Salicaceae	2.2	*	*	*	*
Total in Top Ten % of Flora	58.5%	72.4%	68.8%	53.6%	59.9%

classification is it closest to the Cold Temperate Grasslands under the Great Basin Shrub-Grasslands (Brown, 1980).

Alcoves, hanging gardens, and seeps are very specialized and variable components of the canyon. These plant communities vary according to directional aspect, amount of sunlight received, depth of alcove, soil type, and amount and duration of water flow. Alcoves at Tsegi are created out of sandstone eroded by vertical movement of water across rock seams. Alcoves range from less than a meter to many meters in size, and may also include prehistoric housing ruins. The species most common to alcove seeps include *Mimulus eastwoodiae* and *Adiantum capillus-veneris.* Other species found in cave seeps include *Mentha arvensis, Selaginella mutica, Platanthera zothecina, Pragmites australis, Carex aurea, Carex lanuginosa, Carex specuicola, Oenotheera elata, Aquilegia micrantha, Epipactis gigantea,* and *Mimulus guttatus.* Another type of seep found in the canyon comes out of a vertical canyon side, usually in loose, sandy soil.

This type of seep receives a greater amount of sunlight in comparison to the hanging gardens in the alcoves. The plant composition in this type of seep includes grasses such as *Avena fatua, Elymus canadensis, Elymus elymoides, Glyceria striata, Hordeum jubatum, Poa annua, Polypogon monspeliensis, Schizachyrium scoparium, Secale cereale,* and *Sphenoopholis obtusata.* Other plants at these sites include *Cymopterus beckii, Apocynum cannabinum, Artemisia ludoviciana, Aster frondosus, Solidago sparsiflora, Lithospermum incisum,* and *Glycyrrhiza lepidota.* There is not a dominant species listed because of the differences of plant components present among various seeps. Seeps and alcoves in this area can harbor endemic, rare, and endangered plant species, such as *Carex specuicola* and *Platanthera zothecina.*

DISCUSSION

The floristic composition of representative plant families of the canyon is similar to the floristic composition of the Navajo Nation as last reported by Mayes and Rominger (1994; Table 1). The canyon has a similar number of *Asteraceae* and *Poaceae* when compared to other similar sites. This is surprising as Tsegi, and the Navajo Nation, are grazed while the national parks used for comparison are not. Perhaps a more detailed study is needed to determine whether or not the grazing affects floristic composition. The differences in the families showing a small percentage of the total probably can be accounted for by the concentration of specialized habitat types, such as alcoves and elevation at each site.

Species considered endemic to the Colorado Plateau by Welsh (1993) include *Calochortus aureus, Platanthera zothecina, Astragalus zionis, Astragalus cottamii, Astragalus sesquiflorus,* and *Cymopterus beckii.* The rare and endangered plants include *Platanthera zothecina,* a candidate species, *Carex specuicola,* a listed threatened plant, and *Nama retrosum, Penstemon pseudoputus, Astragalus cottami,* and *Cymopterus beckii,* whose populations are being watched. *Aletes sessiliflorus,* identified by L. Constance, and *Cymopterus beckii* were new reports for the state of Arizona.

Introduced species are listed in Table 2. These exotic plants species comprise about 10% of the total plant population of the canyon. Many of the weedy herbs may have been introduced by domestic grazing animals, whose feed is supplemented with commercial hay, and also by the disturbing of the land by off-road vehicles. Three introduced plants, *Tamarix ramosissima, Elaeagnus angustifolia,* and *Ulmus pumila* were introduced purposely in the Southwest as shade trees and to aid in erosion control (Welsh 1993). Of these, *E. angustifolia* is considered harmful in the canyon by the National Park Service. Attempts are currently being made to keep it out of Betatakin National Monument (Melberg 1996).

There is evidence that suggests that the inner canyon has changed in the last 150 years. In 1916, L.C. Whitehead (MNA) collected *Epipactis gigan-*

TABLE 2. EXOTIC PLANTS FOUND IN TSEGI CANYON. [1]Exotics found in Navajo Monument not listed in Brotherson et. al., 1978. [2]State of Arizona Designated exotic plant species.

Species Name	Common Name	Origin
Monocotyledoneae		
Poaceae		
Avena fatua	Wild Oats	Eurasia
Bromus tectorum	Cheat Grass	Eurasia
Dactylis glomerata	Orchard Grass	Eurasia/Africa
Erenopyrm triticeum	Annual Wheat Grass	Central Asia
Polypogon monospeliensis	Rabbitfoot Grass	Eurasia/Africa
Polypogon semiverticillatus	Water Polypogon	Eurasia
Secale cereale	Cultivated Rye	Eurasia
Dicotyledoneae		
Asteraceae		
Artemisia absinthium	Absinthe	Europe
Cirsium vulgare	Bull Thistle	Eurasia
Latuca serriola	Prickly Lettuce	Europe
Sonchus asper	Spiny Sow Thistle	Europe
Tagetes patula	Marigold	Mexico
Taraxacum officinale	Dandelion	Eurasia
Tragopogon dubius[1]		Eurasia
Xanthium strumarium	Cocklebur	Eastern U.S.
Brassicaceae		
Capsella bursa-pastoris	Shepherds Purse	Europe
Corisppora tenella[1]	Musk mustard	Asia
Descurainia sophia		Europe
Sisymbrium altissimum	Tumble Mustard	Europe
Chenopodiaceae		
Kochia scoparia	Summer Cypress	Eurasia
Salsola iberica	Tumble Weed	Asia
Elaegnaceae		
Elaeagnus angustifolia	Russian Olive	Europe
Fabaceae		
Trifolium repends[1]	White Clover	Europe
Medicago lupulina	Hop Clover	Europe
Medicago staiva	Alfalfa	Europe
Melilotus album	White Sweet Clover	Europe
Geraniaceae		
Erodium cicutarium	Storkbill	Europe
Lamiaceae		
Draccocephalum tymiflorum	Horehound	Eurasia
Marrubium vulgare		Eurasia
Plantaginaceae		
Plantago lanceolata		Eurasia
Plantago major[1]	Broadleaf Plantain	Europe
Ranunculaceae		
Ranunculus testiculatus[1]	Bur Buttercup	Eurasia
Scrophulariaceae		
Verbascum thapsus	Wooly Mullein	Eurasia
Tamaricaceae		
Tamarix ramosissima	Tamarack	Eurasia
Ulmaceae		
Ulmus pumila[1]	Siberian Elm	Asia
Zygophyllaceae		
Tribulus terrestris[2]	Puncture Vine	Eurasia

tea, Pinus edulis, Abies concolor, Equisetum hiemale, Salix exigua, Populus tremuliodes, and *Quercus gambelii* from Tsegi Canyon. All of these species are now present in the canyon, though the *Abies* is now only found in one side canyon northeast of the Keet Seel ruin. Of these, *Epipactis, Equisetum, Salix,* and *Populus* are usually found in more mesic soils. Clute (1920) described the canyon as containing desert plants and some mesophytes. He also stated, that at the time, there was a layer of "peat two feet thick" that contained snail shells. He felt that this was evidence of the previously reported lakes and swamps. The most extensive historical collection was done by the Wetherill family in the 1930's. Most of the plants in that collection are also found at the present and are indicated as such in the floristic appendix of this paper. Plants included in the Wetherill collection (Wyman

1951) that were not found in the present study or listed by Brotherson et al. (1978) in their survey of Navajo National Monument include *Abronia fragrans, Cologonia angustifolia, Amaranthus retroflexus, Juniperus communis, Bromus anomalus, Bromus vulgaris, Pachystema myrsinites, Oenothera lavandulifolius, Eriophyllum lanosum, Achillea lanulosa, Setaria viridis, Pedicularis centranthera, Bouteloua eriopoda, Sporobolus pulvinatus,* and *Nicotiana trigonophylla.* These particular plant species could possibly survive in the microhabitats of the present Tsegi drainage. Why they were not found during my survey periods is unknown. Although One Side Canyon was in the past called "Water lily Canyon", I could find no evidence of water lilies collected in the early 1900's.

Conclusion

Tsegi Canyon is a complex canyon of numerous drainages. It has experienced a large amount of erosion in the last hundred years. This has changed the nature of the bottom of the canyon from marshy pools to a faster moving creek. Erosion has lowered the bottom of the creek and that lowered the water table and affected small seeps along the sides of the canyon. Some marshy areas still exist, but only in limited areas in protected side-canyons. There is a good possibility that changes in the fauna and flora have occurred along with local extinctions. Hopefully, more studies will be done here to document the flora and fauna in this remote area of Arizona. Information needs to be gathered to create an effective means of preserving this riparian area while still allowing usage by local inhabitants.

Acknowledgments

I would like to thank Dr. Tina Ayers and Dr. Randy Scott for their guidance in preparing this paper, Dr. H. David Hammond for his help with identifying plants I found so frustrating, Bruce Melberg and the staff at Navajo National Monument for their help and support, Dr. Joseph E. Laferriere for his review and helpful comments, and my husband, Gordon, my sons, Lyle and Curtis, and fellow botanist Abril Perez, who accompanied me on several trips.

Literature Cited

Bonham, C. D. 1989. Measurements for Terrestrial Vegetation. John Wiley and Sons.

Brotherson, J. D., G. Nebeken, M. Skougard, and J. Fairchild. 1987. Plants of Navajo National Monument. Great Basin Naturalist 38(1):19–30.

Brotherson, J. D., Rushforth, S. R., and Johansen, J. R. 1983. Effects of Long-term Grazing on Cryptogam Crust Cover in Navajo National Monument, Ariz. Journal of Range Management 36(5):579–581.

Brown, D. E., Lowe, C. H., and Pase, C. P. 1980. A Digitized Systematic Classification for Ecosystems with an Illustrated Summary of the National Vegetation of North America. USDA Forest Service General Technical Report RM-73.

Clay-Poole, S. T. 1980. Pollen Flora and Paleoecology of Holocene Alluvial Tsegi and Naha Formations, Northeast Arizona. Northern Arizona University. Flagstaff, AZ.

Clute, W. N. 1920. Notes on the Navajo Region. The American Botanist. 26(2):38–47.

Dean, J. S. 1969. Chronological Analysis of Tsegi Phase Sites in Northeastern Arizona. University of Arizona Press. Tucson, AZ.

Hack, J. T. 1945. The Changing Physical Environment of the Hopi Indians of Arizona. Papers of the Peabody Museum of American Archaeology and Ethnology, Havard University. 35(1).

Hastings, R. H. and Turner R. M. 1965. The Changing Mile. University of Arizona Press.

Heil, K. D., Porter, J. M., Fleming, R., and Romme, W. H. 1993. Vascular Flora and Vegetation of Capitol Reef National Park, Utah. USDI, National Park Service Technical Report NPS/NAUCARE/NRTR-93/01.

Kartesz, J. T., and Kartesz, R. 1890. A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland, Vol. II, The Biota of North America. The University of North Carolina Press. Chapell Hill, NC.

Kierstead, J. R. 1981. Flora of Petrified National Park, Arizona. Thesis. Northern Arizona University.

Mayes, V. O. and Rominger, J. M. 1994. Navajoland Plant Catalog. National Woodlands Publishing Company.

Phillips, B. G., Phillips, A. M. and Bernzott, M. S. 1987. Annotated Checklist of Vascular Plants of Grand Canyon National Park. Grand Canyon Natural History Association, Monograph 7.

Rowlands, P. G. 1994. Colorado Plateau Vegetation Assesment and Classification Manual. USDI, National Park Service, Technical Report NPS/NAUCPRS/NRTR-94/06.

U.S. Department of Commerce, 1996 Climatological Data.

Welsh, S. L., Atwood, N. D., Higgins, L. C., and Goodrich, S. 1993. A Utah Flora, Great Basin Naturalist Memooirs No. 9.

Wyman, L. C. 1951. The Ethnobotany of the Kayenta Navajo. University of New Mexico Press. Albuquerque NM

Appendix 1

Flora of Tsegi Canyon

The nomenclature in this flora follows Kartesz (1980). The letter designation for endemic species is 'A', exotic species is 'B', federal category C2 is 'C2', fegeral category C3 is 'C3', federally listed threatened and endangered is 'T', those included in the Wetherill collection are 'W'.

Selaginellaceae

Selaginella mutica D. C. Eaton. Perennial; moist areas under cave seeps, Apr.–June.

Equisetaceae

Equisetum arvense L. Perennial; sandy, moist areas by springs and seeps, June–Aug.

Equisetum hyemale L. Perennial; sandy, moist area near upper Laguna Creek. June–Aug., W.

Adiantaceae

Adiantum capillus-veneris L. Perennial; cave seeps and hanging gardens, May–Aug. W.

Aspleniaceae

Woodsia oregana D.C. Eaton. Perennial; seep running over crack in sandstone cliff, Sept.

Cupressaceae

Juniperus osteosperma (Torr.) Little. Evergreen Tree; widespread on sandy flats, W.

Ephedraceae

Ephedra viridis Cov. Evergreen shrub; widespread on sandy flats, W.

Pinaceae

Abies concolor (Gord. & Glend.) Lindl. Evergreen tree; shady, upper areas of Keet Seel Canyon.
Pinus edulis Engelm. Evergreen tree; widespread on sandy flats, W.
Pinus ponderosa Dougl. Evergreen tree; sometimes found in side canyons. W.
Pseudotsuga menziesii (Mirbel) Franco. Evergreen tree; found in shady side canyons, W.

Agavaceae

Yucca angustissima Engelm. ex Trel. Perennial; found on sandy flats, flowers in June, W.
Yucca baccata var. baccata Torr. Perennial; north slope of Betatakin canyon, W.

Commelinaceae

Tradescantia occidentalis (Britt.) Smyth. Perennial herb; trail to Betatakin ruins and sandy areas in side canyons, May–June, W.

Cyperaceae

Carex aurea Nutt. Perennial herb; seeps and springs, June–Aug.
Carex lanuginosa Michx. Perennial herb; seep near Keet Seel Ruins, June–Aug.
Carex rossii F. Boott. Perennial herb; Betatakin canyon by trail bench, June–Aug.
Carex specuicola J. T. Howell. Perennial herb; hanging gardens and seeps, June–Aug., A, T.
Eleocharis palustris (L.) R. & S. Perennial herb; Betatakin creek, June–Aug.
Scirpus pungens Vahl. Perennial herb; moist creek bottoms, June–Aug.

Juncaceae

Juncus arcticus Willd. Perennial herb; moist creek bottoms, May–Aug., W.
Juncus bufonius L. Perennial herb; moist sand, lower sidecanyons, June–Aug.
Juncus saximontanus A. Nels. Perennial herb; by small creek, May–June, W.

Liliaceae

Allium macropetalum Rybd. Perennial herb; sandy flats, Apr.–May, W.
Androstephium breviflorum Wats. Perennial herb; trail to Betatakin, Apr.–May. W.
Calochortus aureus Wats. Perennial herb; sandy flats, June–July. W.
Fritillaria atropurpurea Nutt. Perennial herb; creekside, Fir Canyon, June–July W.
Smilacina stellata (L.) Desf. Perennial herb; moist canyon bottoms, June–Aug. W.

Orchidaceae

Corallorhiza maculata Raf. Perennial herb; lower Betatakin canyon, under trees, June–July, W.
Epipacis gigantea Dougl. ex. Hook. Perennial herb; hanging gardens and seeps, June–Aug., W.
Platanthera zothecina Higgins & Welsh. Perennial herb; hanging gardens and cave seeps, including Betatakin ruin, July–Aug. A, C2, W.

Poaceae

Agrostis exarata Trin. Perennial herb; beside small stream in Keet Seel Canyon, June.
Arista purpurea Nutt. Perennial herb, dry sandy soil, May–June, W.
Avena fatua L. Annual herb; found in moist sand and flat seeps, July–Sept., B.
Bouteloua curtipendula (Michx.) Torr. Perennial herb; tree shade in side canyons, Aug.–Sept., W.
Bouteloua gracilis (H.B.K.) Lag. ex Steudel. Perennial herb; found on sandy flats with pinion trees, June–Sept., W.
Bromus carinatus H. & A. Perennial herb; sandy soil in side canyon, May–June, W.
Bromus tectorum L. Annual herb; found on all sandy flats and near streams, April–Sept., B, W.
Dactylis glomerata L. Perennial herb; sandy soil beside creek, July–Aug., B.
Elymus canadensis L. Perennial herb; moist sand near seep, Aug.–Sept.
Elymus cinereus Scribn. & Merr. Perennial herb; sandy soil beside creek, Aug.–Sept.
Elymus elymoides (Raf.) Swezey. Perennial herb; wet sand of seep, April–May, W.
Elymus smithii (Rybd.) Gould. Perennial herb; sandy areas of lower canyon, April–June.
Elymus trachycaulus (Link) Gould ex Shinners. Perennial herb; sandy soil, May–June.
Eremopyrum triticeum (Gaetrn.) Nevski. Annual herb; dry sandy soil beside creek, July–Aug., B.
Glyceria striata (Lam.) A. S. Hitch. Perennial herb; wet sandy soil by seep, June–July.
Hilaria jamesii (Torr.) Benth. Perennial herb; dry sandy soil, June–July.

Hordeum jubatum L. Perennial herb; wet sandy soil by seep, June–July.
Hordeum pusilium Nutt. Annual herb; dry sandy soil, June–July.
Muhlenbergia andina (Nutt.) A. S. Hitch. Perennial herb; found in sandy soil of dry creek bed, Aug.–Sept., W.
Muhlenbergia pungens Thurben in Gray. Perennial herb; dry sandy soil, Aug.–Sept., W.
Monroa squarrosa (Nutt.) Torr. Annual herb; found on sandy soil, July–Aug., W.
Pragmites australis (Cav.) Trin. ex Steudel. Tall perennial herb; found at Betatakin ruin, June–Sept., W.
Poa pratensis L. Perennial herb, moist soil in shade, June–Sept.
Polypogon semiverticillatus (Forsskal) Hylander. Perennial herb, moist, sandy soil, June–July, B.
Puccinellia nuttalliana (Schultes) A. S. Hitch. Perennial herb, sand by seep, June–July.
Schizachyrium scoparium (Michx.) Nash in Small. Perennial herb, sand by seep, July–Aug.
Secale cereale L. Annual herb, moist sand by seeps, July–Aug., B.
Sphenopholis obtusata (Mitchx.) Scribn. Annual herb, wet sandy soil, July–Aug.
Sporobolus cryptandrus (Torr.) gray. Perennial herb, dry sand, Aug.–Sept., W.
Stipa comata Trin. & Rupr. Perennial herb, sandy soil, May–June, W.
Stipa hymenoides R. & S. Perennial herb, dry sand, May–June, W.
Vulpia octoflora Walter. Annual herb, sandy soil creekside, May–June, W.

Typhaceae

Typha domingensis Pers. Perennial, below Keet Seel ruin and side canyons, June–Sept.

Aceraceae

Acer negundo L. Tree, near streams and seeps, May–Oct., W.

Amaranthaceae

Amaranthus blitoides Wats. Annual herb, sandy soil near streams, July–Sept.

Anacardiaceae

Rhus aromatica var. *trilobata* (Nutt.) Gray. Shrub, upper side canyon, June–Aug., W.
Toxicodendron rydbergii (Small) Greene. Small shrub, upper side canyons, June–Sept., W.

Apiaceae

Aletes sessiliflorus Theobald & Tseng. Perennial herb, sand by streams, June–July, new report.
Cymopterus acaulis (Pursh) Raf. Perennial herb, sand under trees, June–July, W.
Cymopterus beckii Welsh & Goodrich. Perennial herb near seeps, June–July, new report, A, C2.
Cymopterus purpureus Wats. Perennial herb, clay soil near trees, June–July.

Apocynaceae

Apocynum cannabium L. Perennial herb, moist sand by seeps, June–Aug.
Apocynum x medium Greene. Perennial herb, moist sand by stream, June–July.

Asclepiadaceae

Asclepias asperula (Decne.) Woodson. Perennial herb, sand, May–June, W.
Asclepias latifolia (Torr.) Raf. Perennial herb, sunny sand, June–July.
Asclepias speciosa Torr. Perennial herb, beside stream, July–Aug., W.
Asclepias subverticillata (Gray) Vail. Perennial herb, sunny canyon sides, June–Aug.

Asteraceae

Ambrosia acanthicarpa Hook. Annual herb, sandy soil, Aug.–Sept., W.
Antennaria neglecta Greene. Perennial herb, shade, sand, May–June, W.
Antennaria parvifolia Nutt. Perennial herb, shade, June, W.
Artemisia absinthium L. Perennial herb, dry sand, July–Aug.
Artemisia campestris L. Perennial herb, dry sandy soil, shade, July–Aug., W.
Artemisia carruthii Wood ex Carruth. Perennial herb, sandy soil, July–Aug.
Artemisia dracunculus L. Perennial herb, shade, June–Aug., W.
Artemisia frigida Willds. Perennial herb, sandy soil, June–Sept., W.
Artemisia ludoviciana Nutt. Perennial herb, moist sand, July–Aug., W.
Artemisia tridentata var. tridentata Nutt. Shrub, common in canyon, June–Aug., W.
Aster frondosus (Nutt)T. & G. Annual herb, moist sand, Aug.–Sept., W.
Aster glaucodes Blake. Perennial herb, creekbed, July–Sept.
Brickellia californica Gray. Perennial subshrub, moist sand, July–Aug., W.
Brickellia microphylla (Nutt.) Gray. Small shrub, sandy soil, Aug.–Oct., W.
Brickellia oblongifolia Nutt. Perennial subshrub, dry clays, May–June.
Chaetopappa ericoides (Torr.) Nesom. Perennial herb, dry sand, June–July, W.
Chrysothamnus depressus Nutt. Low shrub, dry creek bottom, July–Sept.
Chrysothamnus nauseosus (Pallas)Britt. Shrub, common in canyon, July–Sept.
Chrysothamnus viscidiflorus (Hook.)Nutt. Shrub, lower canyon, July–Sept., W.

Cirsium calcareum var. *pulchellum* (Greene)Welsh. Perennial herb, creek bottoms, July–Sept.
Cirsium vulgare (Savi)Ten. Biennial herb, creek bottom, July–Sept.
Conyza canadensis (L.)Cronq. Annual herb, creek bottom, June–Sept.
Erigeron bellidiastrum Nutt. Annual herb, sandy soil, July–Aug.
Erigeron compactus Blake. Perennial herb, dry sand, May–June.
Erigeron eatonii Gray. Perennial herb, sand, shade, May–June, W.
Erigeron flagellaris Gray. Perennial herb, near seep, April–May.
Erigeron lonchophyllus Hook. Perennial herb, moist sand, July–Aug.
Erigeron pumilis Nutt. Perennial herb, sandy soil, June–July.
Erigeron speciosus (Lindl.) D.C. Perennial herb, sandy soil July–Aug.
Erigeron utahensis Gray. Perennial herb, sandy soil, sun, May–June.
Gnaphalium chilense Sprengel. Annual herb, moist sand, July–Aug.
Gutierrezia sarothrae (Prush)Britt. & Rusby. Small shrub, sand, sun, July–Sept., W.
Haplopappus ameriodes (Nutt.)Gray. Perennial herb, dry clays, May–June.
Haplopappus spinulosus (Prush)D.C. Perennial herb, sand, shade, July–Aug.
Helianthus petiolaris Nutt. Annual herbs, sand, sun, July–Aug., W.
Heterotheca villosa (Pursh)Shinn. Perennial herb, sandy soil, common, July–Sept., W.
Hymenopappus filifolius Hook. Perennial herb, west facing walls, June–July, W.
Hymenoxys acaulis (Pursh)Parker. Perennial herb, sandy soil, May–June, W.
Lactuca serriola L. Biennial herb, sandy soil, Aug.–Sept., B, W.
Lygodesmia grandiflora (Nutt.)T.&G. Perennial herb, clay soil, June–July.
Machaeranthera canescens (Pursh)Gray. Biennial herb, sandy soil, July–Aug., W.
Machaeranthera grindeliodes (Nutt.)Shinn. Perennial herb, dry sand, June–July, W.
Petradoria pumila (Nutt.)Greene. Perennial herb, dry sand, June–July.
Psilostrophe sparsiflora (Gray)W.Nels. Perennial herb, sandy soil, June–Aug., W.
Senecio douglasii DC. Perennial herb, sandy soil below seep, July–Aug.
Senecio multilobatus T.&G. Perennial herb, sandy soil, shade, May–June, W.
Senecio spartioides T.&G. Perennial herb, sandy soil, Aug.–Sept., W.
Solidago canadensis L. Perennial herb, dry creek bottom, July–Sept., W.
Sonchus asper (L.)Hill. Annual herb, moist sand, July–Sept., B.
Stephanomeria exigua Nutt. Annual herb, sandy soil, July–Aug.
Stephanomeria tenuifolia (Torr.)Hall. Perennial herb, sandy soil, July–Aug.
Tagetes patula L. Annual herb, moist sandy soil, July–Aug., B.
Taraxacum officinale Weber ex Wiggers. Perennial herb, moist soil, May–Sept., B.
Thelesperma subnudum Gray. Perennial herb, sandy soil, sun, June–July, W.
Tragopogon dubius Scop. Biennial herb, dry sand, June–Aug., B.
Verbesina enceliodes (Cav.)Benth.&Hook. Annual herb, sandy soil, July–Aug.
Wyethia scabra Hook. Perennial herb, creekbed sand, June–July.
Xanthium strumarium L. Annual herb, moist sand, June–Aug., B.

Berberidaceae

Mahonia repens (Lindl.)G.Don. Small evergreen shrub, shade, W.

Betulaceae

Betula occidentalis Hook. Small trees, along creek sides, May–Aug.

Boraginaceae

Cryptantha bakeri (Greene)Payson. Biennial herb, sandy soil, May–June.
Cryptantha crassisepala (T.&G.)Greene. Annual herb, sand, sun, May–June, W.
Cryptantha flava (A.Nels.)Payson. Perennial herb, sandy soil, May–June.
Cryptantha fulvocanescens (Wats.)Payson. Perennial herb, dry sand, June–July.
Cryptantha inaequata Johnston. Perennial herb, moist sand below seep, June–July.
Cryptantha cinerea (Torr.)Cronq. Perennial herb, sandy soil, sun, May–June.
Cryptantha circumscissa (H.&A.)Johnston. Annual herb, sandy soil, May–June.
Lappula occidentalis (Wats.)Greene. Annual herb, dry sand, April–May, W.
Lithospermum insicum Lehm. Perennial herb, moist sand, June–Aug.

Brassicaceae

Arabis perennans Wats. Perennial herb, sand, shade, June–Aug., W.
Arabis pulchra var. *pallens* Jones. Perennial herb, sandy soil, May–June.
Capsella bursa-pastoris (L.)Medicus. Annual herb, near trails, May–June, B.
Chorispora tenella (Pallas)DC. Annual herb, along trails, June–July, B.
Descurainia pinnata (Walter)Britt. Annual herb, sandy soil, May–June, W.

Descurainia sophia (L.) Webb ex Prantl. Annual herb, trail side, May–June, W.
Dithyrea wislizenni Engelm. in Wisliz. Annual herb, sand, May–June, W.
Lepidium montanum var. *spathulatum* (Robins.)C.L.Hitch. Perennial herb, sandy soil, July–Aug., W.
Lepidium virginicum L. Annual herb, moist sand by seep, July–Aug.
Lesquerella intermedia (Wats.)Heller. Perennial herb, sandy soil, April–June, W.
Pysaria newberryi Gray. Perennial herb, sandy soil, June–July.
Sisymbrium altissimum L. Annual herb, sand dunes, July–Sept., B.
Stanleya pinnata (Pursh)Britt. Perennial herb, clays, June–Aug.
Streptanthella longirostris (Wats.)Rydb. Annual herb, sandy soil, shade, May–June.
Strepthanthus cordatus Nutt. ex T.&G. Perennial herb, sand, shade, June–Aug., W.
Thelypodium integrifolium (Nutt.)Britt.&Rose. Biennial herb, sandy soil, June–Aug.
Thlaspi montanum L. Annual herb, moist sand below seep, April–May.

Cactaceae

Coryphantha vivipara (Nutt.)Britt.&Rose. Perennial, sandy soil, shade, June.
Echinocereus triglochidiatus Englem. Perennial, sandy soil, shade, June.
Opuntia erinacea Englem. Perennial, sandy soil, sun, June.
Opuntia fragilis (Nutt.) Haw. Perennial, sandy soil, shade, June, W.
Opuntia phaeacantha var. *discata* (Griffiths)Benson & Walkington. Perennial, below Betatakin ruin, June.
Opuntia polycantha Haw. Perennial, sandy soil, sun, June.
Opuntia whipplei Engelm. Perennial, sandy soil, sun, June.
Sclerocactus whipplei (Engelm.)Britt.&Rose. Perennial, sandy soil, shade, June.

Cannabaceae

Humulus americanus Nutt. Perennial herb, dry creek bottom, June–July, W.

Capparaceae

Cleome serrulata Pursh. Annual herb, sandy soil, sun, May–July, W.

Caprifoliaceae

Symphoricarpos oreophilius Gray. Shrub, sandy soil, shade, June–Aug., W.

Caryophyllaceae

Arenaria fendleri Gray. Perennial herb, sandy soil, sun, May–June, W.
Silene menziesii Hook. Perennial herb, sandy soil, shade, May–June, W.

Chenopodiaceae

Atriplex canescens (Pursh)Nutt. Shrub, sandy soil, sun, July–Aug.
Atriplex confertifolia (Torr.&Frem)Wats. Shrub, sandy soil, July–Aug.
Atriplex powellii Wats. Annual herb, sandy soil below seep, July–Aug.
Chenopodium album L. Annual herb, sandy soil, shade, June–Aug., B.
Chenopodium leptophyllum (Moq.)Wats. Annual herb, sandy soil, July–Aug.
Chenopodium rubrum L. Annual herb, sandy soil, July–Aug.
Corispermum villosum Rybd. Annual herb, sandy soil, July–Sept.
Kochia scoparia (L.)Schrader. Annual herb, sandy soil, July–Aug., B.
Salsola iberica Sennen & Pau. Annual herbs, sandy soil, sun, July–Sept., B, W.
Sarcobatus vermiculatus (Hook.)Torr in Emory. Shrub, sandy soil, July–Sept.
Suaeda torreyana Wats. Perennial subshrub, sandy soil, July–Aug.

Cornaceae

Cornus sericea L. Shrub, streamside, shade, May–Sept., W.

Elaegnaceae

Elaeagnus angustifolia L. Small tree, near creeks, May–Sept., B.
Shepherdia rotundifolia Parry. Evergreen shrub, cliffsides, W.

Ericaceae

Arctostaphylos patula Greene. Shrub, sand, near creek, May–Sept., W.

Euphorbiaceae

Euphorbia lurida Engelm. Perennial herb, sand, sun, June–Aug.
Euphorbia micromera Boiss. Annual herb, sand, sun, July–Sept.

Fabaceae

Astragalus amphioxys Gray. Perennial herb, dry sand, sun, June–July, W.
Astragalus ceramicus Sheldon. Perennial herb, sandy soil, June–July.
Astragalus cottamii Welsh. Perennial herb, sandy soil, shade, June–July, A, C3.
Astragalus flavus Nutt. ex T.&G. Perennial herb, sandy soil, May–June.
Astragalus lentiginosus Dougl. ex Hook. Perennial herb, sandy soil, sun, May–June.

Astragalus mollissimus Torr. Perennial herb, sandy soil, June–July, W.
Astragalus sesquiflorus Wats. Perennial herb, sand on canyon sides, June–Sept., A, W.
Astragalus zionis Jones. Perennial herb, along trail, May–June, A.
Glycyrrhiza lepidota Pursh. Perennial herb, moist sand, shade, July–Aug.
Lathyrus brachycalyx Rybd. Perennial herb, sand, shade, July–Aug., W.
Lupinus argenteus Pursh. Perennial herb, sand, sun, June–Aug.
Medicago lupulina L. Annual herb, sand near creek, June–July, B.
Medicago sativa L. Annual herb, sandy soil, sun, July–Sept., B.
Melilotus alba Medic. Annual herb, sand, shade, June–July, B.
Psoralidium lanceolatum (Pursh)Rydb. Perennial herb, sandy soil, June–July.
Trifolium repens L. Perennial herb, sand near creek, June–July, B.

Fagaceae

Quercus gambelii Nutt. Small trees, sandy soil, canyon sides, May–Sept., W.

Fumariaceae

Corydalis aurea Willd. Annual herb, sandy soil, shade, June–July, W.

Gentianaceae

Swertia radiata (Kellogg) Kuntze. Perennial herb, sandy soil; June–Sept.

Geraniaceae

Erodium cicutarium (L.)L'Her. Annual herb, sand, sun, May–Sept., W.
Geranium caespitosum James. Perennial herb, sandy soil, shade, June–Aug., W.

Grossulariaceae

Ribes cereum Dougl. Shrub, sand, shade, May–Sept., W.
Ribes inerme Rydb. Shrub, side canyons, shade, June–Sept.
Ribes leptanthus Gray. Shrub, side canyons, shade, June–July, W.

Hydrangeaceae

Fendlera rupicola Gray. Shrub, sandy soil, sun, May–July, W.

Hydrophyllaceae

Nama retrosum J.T. Howell. Annual herb, sand dunes, sun, June–July, A, C3, W.
Phacelia ivesiana Torr. in Ives. Annual herb, sandy soil, sun, May–June.

Lamiaceae

Dracocephalum thymiflorum L. Annual herb, sandy soil, near creek, June–July, B.
Hedeoma drummondii Benth. Annual or perennial herb, sand, June–July.
Marrubium vulgare L. Perennial herb, sandy soil, Aug.–Sept., B.
Mentha arvensis L. Perennial herb, moist sand, shade, Aug.–Sept., W.
Poliomintha incana (Torr.)Gray. Shrub, sandy soil, May–June, W.

Linaceae

Linum aristatum Engelm. Annual herb, sandy soil, Aug.–Sept.
Linum perenne L. Perennial herb, sandy soil, shade, July–Aug.

Loasaceae

Mentzelia albicaulis Dougl. ex Hook. Annual herb, sandy soil, June–July.

Malvaceae

Sphaeralcea parvifolia A. Nels. Perennial herb, sand, sun, May–July.

Nytaginaceae

Mirabilis linearis (Pursh)Heimerl. Perennial herb, sandy soil, July–Aug., W.
Mirabilis multiflora (Torr.)Gray in Torr. Perennial herb, sand, shade, July–Aug.
Mirabilis oxybaphoides (Gray)Gray in Torr. Perennial herb, sandy soil, Aug.–Sept.
Tripterocalyx carneus (Greene)Galloway. Annual herb, sand, sun, July–Aug., W.

Onagraceae

Epilobium ciliatum Raf. Perennial herb, moist sand, shade, June–Aug., W.
Gayophytum racemosum T.&G. Annual herb, dry sand, sun, May–June.
Oenothera caespitosa Nutt. Perennial herb, sand, beside trail, June–July.
Oenothera elata H.B.K. Biennial herb, sandy, shade, July–Sept.
Oenothera pallida Lindl. Annual herb, sand, sun, June–July, W.

Orobanchaceae

Orobanche multiflora Nutt. Perennial herb, near *A. tridentata* Nutt., June–July, W.

Plantaginaceae

Plantago lanceolata L. Perennial herb, sandy soil, beside trails, May–June, B.
Plantago major L. Perennial herb, moist sand, June–Aug., B.

Plantago patagonica Jacq. Annual herb, dry sand, near trail, May–June, W.

Polemoniaceae

Gilia aggregata (Pursh)Sprengel. Perennial herb, sandy soil, sun, June–Aug., W.
Gilia leptomeria Gray. Annual herb, sandy soil, sun, June–July.
Gilia longiflora (Torr.)D.Don. Annual herb, sandy soil, shade, June–July, W.
Leptodactylon pugens (Torr.)Nutt. Subshrub, sand, sun, May–July, W.

Polygonaceae

Erigonum alatum Torr. in Sitg. Perennial herb, sandy soil, sun, May–July, W.
Erigonum cernuum Nutt. Annual herb, sandy soil, Aug.–Sept.
Erigonum microthecum Nutt. Small shrub, sandy soil, Aug.–Sept., W.
Polygonum aviculare L. Annual herb, sandy soil, Aug.–Sept.
Polygonum douglassi Greene. Annual herb, sandy soil, June–July.

Portulaceae

Portulaca oleraceae L. Annual herb, moist sand, June–July.
Portulaca retusa Engelm. Annual herb, sand behind trail, June–July.
Talium parviflorum Nutt. Perennial herb, sandy depressions, May–June.

Primulaceae

Androsace septentrionalis L. Annual herb, sandy soil, shade, June–July, W.

Ranunculaceae

Aquilegia micrantha Eastw. Perennial herb, hanging gardens, June–July, W.
Clematis lingusticifolia Nutt. Woody vine, canyon sides, shade, June–July, W.
Delphinium andersonii Gray. Perennial herb, sand along trail, June–July, W.
Ranunculus cymbalaria Pursh. Perennial herb in marshy areas, May–Sept., W.
Ranunculus testiculatus Crantz. Annual herb, sandy soil, sun, May–June, B.
Thalictrum fendleri Engelm. Perennial herbs, sand, shade, June–Aug., W.

Rhamnaceae

Rhamnus betulifolia Greene. Shrub, above pool, shade, June.

Rosaceae

Amelanchier alnifolia (Nutt.)Nutt. Shrub, sandy soil, shade, May–June.
Amelanchier utahensis Koehne. Shrub, sandy soil, sun, May–June, W.
Cercocarpus intricatus Wats. Shrub, sand, sun, May–June, W.
Cercocarpus montanus Raf. Shrub, sandy soil, partial shade, June–July.
Holodiscus dumosus (Nutt.)Heller. Shrub, sandy soil, June–July, W.
Prunus angustifolia Marsh. Small trees, Keet Seel ruin, May–July.
Prunus virginiana L. Small tree, beside streams, June–July, W.
Pursia mexicana (D.Don)Welsh. Shrub, sandy soil, sun, May–June, W.
Pursia tridentata (Pursh)DC. Shrub, sandy soil, sun, May–June, W.

Rubiaceae

Galium aparine L. Annual herb, moist sand, shade, June–Aug.

Salicaceae

Populus angustifolia James. Tree, sandy soil, by streams, May.
Populus fremontii Wats. Tree, sand, along streams, May.
Salix exigua Nutt. Shrub, sand, sun, along streams, May–June.
Salix laevigata Bebb. Small tree, sand, along stream, May–June, W.
Salix lasiolepis Benth. Shrub, sand, along stream, May–June.
Salix monticola Bebb. ex Coult. Shrub, moist sand, May–June.

Santalaceae

Comandra umbellata (L.)Nuatt. Perennial herb, sandy soil, sun, June–July, W.

Saxifragaceae

Heuchera parvifolia Nutt. in T.&G. Perennial herb, sandy soil, shade, June–July, W.

Scrophulariaceae

Castilleja chromosa A. Nels. Perennial herb, sandy soil, June–July.
Castilleja linariifolia Benth. Perennial herb, sandy soil, shade, May–June, W.
Cordylanthus wrightii Gray. Annual herb, sandy soil, shade, July–Aug., W.
Mimulus eastwoodiae Rydb. Perennial herb, hanging gardens, July–Aug.
Mimulus guttatus DC. Perennial herb, moist sand, shade, June–July.
Mimulus rubellus Gray. Annual herb, sandy soil, shade, July–Aug.
Penstemon barbatus (Cav.)Roth. Perennial herb, sand, July–Aug., W.

Penstemon comarrhenus Gray. Perennial herb, sand, sun, June–July, W.
Penstemon eatonii var. *undosus* Jones. Perennial herb, sand, shade, May–June, W.
Penstemon pseudoputus (Crosswhite) N.Holmgren. Perennial, sand, June–July, A, C3.
Penstemon rostriflorus Kellogg. Perennial, sand, shade, June–July.
Verbascum thapsus L. Biennial, sand, sun, July–Aug., B.
Veronica pergrina L. Annual herb, moist sand, June–July.

Solanaceae

Chamaesaracha coronopus (Dunal)Gray. Perennial herb, sandy soil, Aug.–Sept., W.
Datura wrightii Regel. Annual herb, sandy soil, partial shade, July–Aug.
Lycium pallidum Miers. Shrub, sand, sun, May–June, W.
Pysalis hederifolia Gray. Perennial herb, sand, sun, July–Aug.
Solanum jamesii Torr. Perennial herb, sand, by trail, July–Aug., W.

Tamaricaceae

Tamarix ramosissima Ledeb. Shrub, sand, along washes, May–June, B.

Ulmaceae

Ulmus pumila L. Tree, along sides of creek, May–June, B.

Valerianaceae

Valeriana acutiloba Rybd. Annual herb, sand, shade, July–Aug., W.

Verbenaceae

Verbena bracteata Lag.&Rodr. Perennial herb, sand, sun, Aug.–Sept.

Viscaceae

Phorodendron juniperinum Gray. Parasitic perennial, found on juniper trees.

Zygophyllaceae

Tribulus terrestris L. Annual herb, sand, sun, July–Aug., B.